International Workshop on Urban Water Reuse

都市における再生水利用に関する国際ワークショップ

January 10th, 2012

Hosted by

Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

City of Kitakyushu

Kyoto University Global COE Program
Global Center for Education and Research on Human Security Engineering for Asian Megacities

Kyoto University CREST Program
Development and Evaluation of Water Reuse Technologies for the Establishment of 21st century type Water Circulation System

International Workshop on Urban Water Reuse

Representative: Seiichiro OKAMOTO
Date: Jan. 10, 2012
Place: International Conference Room, Kitakyushu International Conference Center

Organized by

Ministry of Land, Infrastructure, Transport and Tourism (MLIT)
City of Kitakyushu
The Global COE Program “Global Center for Education and Research on Human Security Engineering for Asian Megacities”
Kyoto University CREST Program - Development and Evaluation of Water Reuse Technologies for the Establishment of 21st century type Water Circulation System

Invited Persons: HU Hong-Ying (Prof., Tsinghua Univ.), LEE Sangho (Prof., KOOKMIN Univ.), TANAKA Hiroaki (Prof., Kyoto Univ.), KITAHASHI Kenji (Mayor of Kitakyushu)
Number of Participants: About 150
Participants:
TAKASHIMA Eijiro, YAMASHITA Mitsumasa (MLIT), HORIE Nobuyuki, MIYAMOTO Ayako (NILIM), TANAKA Fumihiko, FUKUNAGA Yasuyuki (City of Kitakyushu), INOUE Ryuji, SHINODA Koji, KUDO Shuichi (City of Fukuoka), OKAMOTO Seiichiro, YAMASHITA Naoyuki, MIZUNO Tadao, TANAKA Shuhei, IHARA Ken (Kyoto Univ.), FUJIKI Osamu (Co-Chair of Japanese mirror committee of ISO/TC224)

Purpose

In the Asian countries of the remarkable economic growth, it is the big issue to address the massive increase in demand for water in urban area. In such a situation, a policy to promote actions such as the international standardization of Japan’s technology, planning is proposed in the growth strategy in our country. As the part, the discussion of a standard for the reclaimed water in urban area is carried out under the Japanese initiative in the northeast Asian standard cooperation forum consisting of Japan, China and Korea.

The purpose of the international workshop is to exchange information about the status of water reuse of each country and the research trend of the advanced technology and to exchange opinions about the policy of future international standardization, gathering the expert and the people in charge of the organization of three countries.

Achievement and Results

At the beginning of workshop, Mr. TAKASHIMA Eijiro, director for Watershed Management of Ministry of Land, Infrastructure, Transportation and Tourism (MLIT) and Mr. KITAHASHI Kenji, Mayor of Kitakyushu city addressed the opening remarks on behalf of the organizer. In their speech, the significance and expectation to the result of workshop were expressed.

In the beginning of keynote speech session, Prof. TANAKA Hiroaki of Kyoto University made a presentation about urban water use in consideration of water safety management. Secondly, Prof. HU Hong-Ying of Tsinghua University gave a lecture titled water reproduction in China and the use - standard and water quality management. From Prof. LEE Sangho of KOOKMIN University, there was a lecture about membrane technology for wastewater reclamation: current and future perspectives.

A panel discussion session followed. In the beginning of the session, there was a report about the trend of international standardization for wastewater reuse and present status of wastewater reclamation in Japan from Mr. TAKASHIMA Eijiro of MLIT. In addition, there was a report about the water reuse from Fukuoka city, and the overview of “water plaza” was introduced from city of Kitakyushu. In this session, it was discussed about the target quality of reclaimed water, the importance of the management system standard for the reclaimed wastewater reuse and so on. Through this workshop, participants were able to deepen the understanding about the need of the cooperation of three countries in the field of water reuse and its international standardization.

On January 11, "International meeting for Reclaimed Wastewater Use in Urban Area” (RWUUA) was held by the committee members. The members visited “Water plaza” in Kitakyushu on January 12.

Membrane experimental facilities in “Water plaza” (Kitakyushu)

都市における再生水利用に関する国際ワークショップ

代 表 者： 岡本誠一郎
開催日時： 2012 年 1 月 10 日
開催場所： 北九州市国際会議場 国際会議室

主　　催： 国土交通省
北九州市
京都大学グローバル COE プログラム　「アジア・メガシティの人間安全保障工学拠点」
京都大学 CREST プログラム　「２１世紀型都市水循環系の構築のための水再生技術の開発と評価」

招 聘 者： HU Hong-Ying (Prof., Tsinghua Univ.), LEE Sangho (Prof., KOOKMIN Univ.), 田中宏明（教授, 京都大学）, 北橋健治（北九州市長）
参加人数： 約 150 名
主な参加者：高島英二郎、山下洋正（国土交通省）、堀江信之、宮本綾子（国土技術政策総合研究所）、田中文彦、福永泰之（北九州市）、井上隆治、篠田好司、工藤修一（福岡市）、岡本誠一郎、山下尚之、水野忠雄、田中周平、井原賢（京都大学）、藤木修（ISO/TC224 国内対策委員会共同議長）、その他地方公共団体、民間企業、コンサルタント等

目的・概要

経済成長の著しいアジア諸国では、都市の水需要の急増への対応が課題となっている。こうした中で、わが国では成長戦略の中で、日本の技術・企画の国際標準化等の取り組みを推進する方針が打ち出されている。その一環として、日本、中国、韓国の 3 か国からなる北東アジア標準協力フォーラムにおいて、日本のイニシアティブのもとで都市における再生水利用の規格の検討が進められている。本国際ワークショップは、上記 3 か国の専門家や関係機関の担当者が集い、各国の再生水事情や最先端技術の研究動向について情報交換するとともに、今後の国際標準化の方向性について意見交換を行うことを目的とするものである。

ワークショップの様子・得られた成果

ワークショップの冒頭では、主催者を代表して国土交通省の高島英二郎流域管理官及び北橋健治北九州市長から開会あいさつがあり、本シンポジウムの意義と成果への期待が表明された。

基調講演では、まず田中宏明京都大学教授より水の安全管理を考慮した都市水利用に関する講演が行われた。Tsinghua 大学の HU Hong-Ying 教授からは中国における水再生とその利用-基準と水質管理と題して講演が行われた。さらに KOOKMIN 大学の LEE Sangho 教授から、下水再利用のための膜技術の現状と将来展望について講演があった。

続いてパネルディスカッションが行われた。セッションの冒頭で、国土交通省の高島氏からは、下水再生水利用の国際規格化の動向と国内の都市域における再生水利用の状況について報告があった。また、福岡市の再生水利用、北九州市のウォータープラザについて報告があった。議論を通じて、再生水利用を進めるうえでの膜技術の重要性や、目標水質の考え方、マネジメントシステム基準の重要性などについて意見交換が行われた。本ワークショップを通じて、再生水分野での 3 か国の協力の必要性や国際基準についての理解を深めることができた。

なお、1 月 11 日には、関係委員による「都市域での排水再生利用に関する国際会議（RWUUA)」が開催され、翌 1 月 12 日には、北九州市ウォータープラザの現地視察が行われた。

パネルディスカッションの状況

都市における再生水利用に関する国際ワークショップ

International Workshop on Reclaimed Water Use in Urban Area

10 January, 2012
Kitakyushu International Conference Center

Organized by
Ministry of Land, Infrastructure, Transport and Tourism,

City of Kitakyushu,

Kyoto University Global COE Program
Global Center for Education and Research on Human Security engineering for Asian Megacities,

Japan Science and Technology,
Core Research for Evolutional Science and Technology,
Development and Evaluation of Water Reuse Technologies for the Establishment of
21st century type Water Circulation System

世界経済を取り巻く厳しい環境の中で、アジアは経済成長のけん引役として期待されています。他方、経済活動に伴って、アジアの多くの国々では、都市への人口と産業の集中が著しく、都市環境、水環境の悪化と都市で急増する水需要に対応するための水資源確保が焦眉の課題となっています。

このような国際的な動向のなか、国土交通省が 2010 年に発表した成長戦略では、日本の技術・規格の国際標準化や投資対象国での採用に向けた取組を推進するという方針が打ち出され、その一環として、日本、中国、韓国の 3 ヶ国からなる「北東アジア標準協力フォーラム」の枠組みを活用し、「都市における再生水利用の規格」の開発に向けた検討が行われています。この度、その 3 回目の会議が、最新の技術開発や水ビジネスの国際展開に向け「北九州ウォーターハブ」構想を推進している北九州市にて開催されることとなりました。

今回のワークショップでは、京都大学 GCOE※や CREST（田中チーム）のメンバーをはじめとする、日中韓の専門家が集まるこの機会を活用し、各国の再生水利用の実情や最先端の研究について紹介するとともに、今後の国際標準化の方向性について意見交換いたします。

※アジアの大都市における人間安全保障の確立のための教育・研究を推進するプログラム

【Time Schedule】

13:30～13:35	○Opening Address: Ministry of Land, Infrastructure, Transport and Tourism
13:35～13:40	City of Kitakyushu
	○Keynote speech
13:40～14:10	「水の安全管理を考慮した都市における水利用」 **Urban Water Use in Consideration of Water Safety Management** Prof. Hiroaki TANAKA (Kyoto University)
14:10～14:40	「中国における下水再生と再利用：規制と水質管理」 **Wastewater Reclamation and Reuse in China -Regulations and Water Quality Management-** Prof. HU Hong-Ying（Tsinghua University）
14:40～15:10	「下水再生のための膜技術：現状と将来展望」 **Membrane Technology for Wastewater Reclamation: Current and Future Perspectives** Prof. LEE, SangHo（KookMin University）
15:10～15:25	brake
	○Panel discussion
15:25～16:55	Theme: 再生水利用の国際展開に向けて - 水質から水安全マネジメントへ - Global Challenge for Reclaimed Wastewater Use-From Water Quality to Water Safety Management for Water Reuse- Coordinator: Prof. Hiroaki TANAKA (Kyoto University) Panelist: Prof. HU Hong-Ying（Tsinghua University） Prof. LEE, SangHo（KookMin University） Mr. Eijirou TAKASHIMA (Director, MLIT) Mr. Fumihiko TANAKA (Director, International Water Business, City of Kitakyushu) Mr. Kouji SHINODA (Director, Sewerage, City of Fukuoka) Dr. Osamu FUJIKI（Co-chairperson, Japanese Mirror Committee of ISO/TC224）
16:55～17:00	○Closing address: Prof. Hiroaki TANAKA (Kyoto University)

－list of PDF－

【Keynote speech】

01-Tanaka

「水の安全管理を考慮した都市における水利用」

Urban Water Use in Consideration of Water Safety Management

Prof. Hiroaki TANAKA (Kyoto University)

02-Hu

「中国における下水再生と再利用：規制と水質管理」

Wastewater Reclamation and Reuse in China-Regulations and Water Quality Management-

Prof. HU Hong-Ying（Tsinghua University）

03-Lee

「下水再生のための膜技術：現状と将来展望」

Membrane Technology for Wastewater Reclamation:Current and Future Perspectives

Prof. LEE, SangHo（KookMin University）

【Panel discussion】

10-discussion

「Discussion points」

11a-Takashima(JP)

11b-Takashima(EN)

「下水再生水利用　国際標準化の取り組みと日本における都市内利用の現状」

Reclaimed Wastewater Use International Standardization Activities and Current State in Urban Area in Japan

Mr. Eijirou TAKASHIMA (Director, MLIT)

12a-Kitakyushu(JP)

12b-Kitakyushu(EN)

「再生水における膜処理の可能性～ウォータープラザ北九州の挑戦～ 」

Potential of Membrane Treatment for Reclaimed Water～A Project by Water Plaza Kitakyushu～

Mr. Fumihiko TANAKA (Director, International Water Business, City of Kitakyushu)

13a-Fukuoka(JP)

13b-Fukuoka(EN)

「福岡市における再生水利用の取り組みについて 」

Reclaimed Water in Fukuoka City

Mr. Kouji SHINODA (Director, Sewerage, City of Fukuoka)

14-Fujiki

「マネジメントシステム規格の潮流と再生水利用 」

Growing tide of management system standards and their potential for reclaimed wastewater use

Dr. Osamu FUJIKI（Co-chairperson, Japanese Mirror Committee of ISO/TC224）

15a-MBR(JP)

15b-MBR(EN)

「日・中・韓再生水セミナーMBR の活用」

City of Kitakyushu

【Poster】

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CREST 田中チーム　プロジェクト概要 「21 世紀型都市水循環系の構築のための水再生技術の開発と評価」

田中宏明[1]、井原賢[1]、山下尚之[1]、中田典秀[1]、清水芳久[1]、高畠寛生[2]、
加藤康弘[3]、小越眞佐司[4]、鈴木穣[5]、水野忠雄[1]、田中周平[1]
([1)]京都大学、[2)]東レ株式会社、[3)]メタウォーター株式会社、[4)]国土技術総合研究所、[5)]土木研究所)

P-2

下水高度処理水による、エストロゲン様作用・抗エストロゲン作用の変化

Change of wastewater effluent estrogenic/anti-estrogenic activities during advanced wastewater treatment

井原賢[1]、 大野満理子[1]、 Vimal Kumar[1]、 成宮正倫[1]、 花本征也[1]、 中田典秀[1]、
山下尚之[1]、 加藤康弘[2]、 青木未知子[2]、 宮川信一[3]、 井口泰泉[3]、 田中宏明[1]
([1)]京都大学、[2)]メタウォーター株式会社, [3)]自然科学研究機構基礎生物学研究所)

P-3

UF Membrane for Sewage Reclamation

Kentaro KOBAYASHI[1], Hironobu SUZUKI[1], Hiroo TAKABATAKE[1], Yuji TANAKA[1],
Yoshinori NISHIDA[2], SunTae LEE[2], Naoyuki YAMASHITA[2], Hiroaki TANAKA[2]
([1)] Toray Industries, Inc. [2)] Kyoto University)

P-4

微生物添加前処理によるウイルス低濃度試料におけるノロウイルス検出感度向上に関する検討

Improvement of the norovirus detection limit by pretreatment performed by adding microorganisms to a sample with low virus concentration

安井宣仁、桜井健介、岡本誠一郎、諏訪守、内田勉
（土木研究所）

P-5

メダカの遺伝子発現プロファイルを用いた下水処理水のバイオアッセイ手法検討

朴 昶範、北村友一、村山康樹、南山瑞彦、鈴木 穣
（土木研究所）

P-6

再生水の利用用途に応じたリスク評価と管理の考え方

Scheme of Risk Assessment and Management for Various Type of Water Reuse Applications

鈴木穣、岡本誠一郎、南山瑞彦、内田勉、北村友一、桜井健介、村山康樹、安井宣仁、
朴昶範、諏訪守
（土木研究所）

P-7

無機膜とオゾンを利用した新しい再生水処理システムの開発

加藤康弘[1]、青木未知子[1]、Wang Hongyang[2]、和田 直也[2]、中田典秀[2]、田中宏明[2]
([1)]メタウォーター株式会社、[2)]京都大学大学院工学研究科）

P-8

21 世紀型都市水循環系の構築 -中国華南地域を適用場として-

Development of 21st Century Type Water Circulation System - Its application in Southern China -

水野忠雄[1]、八十島誠[2]
([1)]京都大学、[2)](株)島津テクノリサーチ）

P-9

Research of Energy Evaluation of in Water Circulation Systems

Masashi OGOSHI, Yoko YAMAMOTO, Shunsuke NISHIMURA, Ayako MIYAMOTO, Junichi YOSHITANI

(National Institute for Land and Infrastructure Management)

P-10

ベトナムダナン市の水環境および水利用の実態調査

Investigation of actual conditions of water environment and water use in Danang, Vietnam

田中周平[1]、原田英典[1]、N.P.H.Lien[1]、Chinagarn Kunacheva[1]、藤井滋穂[1]、Tran Van Quang[2]、Hoang Hai[2]、 V.D.N.Khoi[2] 、Binaya Shivakoti[3]、濱島健太朗、今田啓介[1]、Dinh Quang Hung[1]、鈴木裕識[1]、林益啓[1]

([1])京都大学、[2]) ダナン工科大学、[3]) 地球環境戦略研究機関)

P-11

紫外線照射による難分解性有機フッ素化合物類の分解処理に関する検討

Decomposition of Perfluorinated Compounds in Aqueous Solution by UV Irradiation

田中周平、原田英典、N.P.H.Lien、Chinagarn Kunacheva、藤井滋穂、河野佑太、林益啓、須藤勇紀、鈴木裕識

(京都大学)

P-12

藻類を用いた光合成阻害試験の基礎的研究

Fundamental study of photosynthetic inhibition assay using algae

大谷 壮介、 盛田 悠平、 日下部 武敏、 清水 芳久

(京都大学)

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夏季における琵琶湖天然有機物（NOM）の生分解性評価

Biodegradability of Lake Biwa Natural Organic Matter (NOM) in Summer

日下部武敏、 秋田泰典、 大谷壮介、 西田昌代、 盛田悠平、 清水大吾、 清水芳久

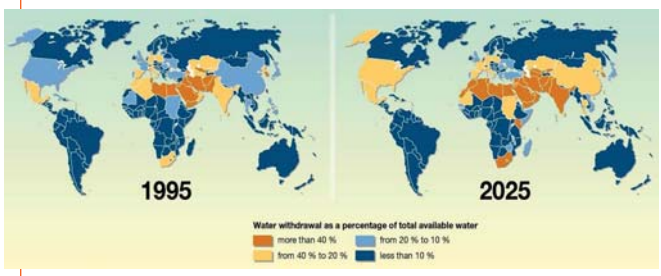
(京都大学)

International Workshop on Reclaimed Water Use in Urban Area -From Water Quality to Water Safety Management for Water Reuse- held on January 10, 2012 at Kitakyushu International Conference Center

Urban Water Use in Consideration of Water Safety Management

Prof. Hiroaki TANAKA
Kyoto University
Research Center for Environmental Quality Management

Developing Global Water Stress (UNEP,2008)



UNEP (2008), Vital Water Graphics - An Overview of the State of the World's Fresh and Marine Waters. 2nd Edition. UNEP, Nairobi, Kenya. ISBN: 92-807-2236-0

Environmentally Sound Technology (EST)

- Agenda 21 Chapter 34
- ESTs are
  - Protect the environment
  - Are less polluting
  - Use all resources in a more sustainable manner
  - Recycle more of their wastes and products
  - Handle residual wastes in a more acceptable manner than the technologies for which they are substitutes
- Wastewater Reclamation and Reuse is an EST

Advantages of Wastewater Reuse

- Recycled wastewater can serve as a more dependable water resource
  - Less affected by drought, close location to water demand, containing useful constituents and heat
- Wastewater reuse leads to reduce water consumption and treatment needs
  - Less costly, reduction of infrastructural needs
- Wastewater reuse can allocate more freshwater for water demand requiring more high quality
  - Environmental protection through reduction of pollutant discharge & preserve natural water cycle
- Water reclamation can contribute to low carbon
  - Reduction of water transport & wastewater treatment

Public Health & Environmental Risk Minimization

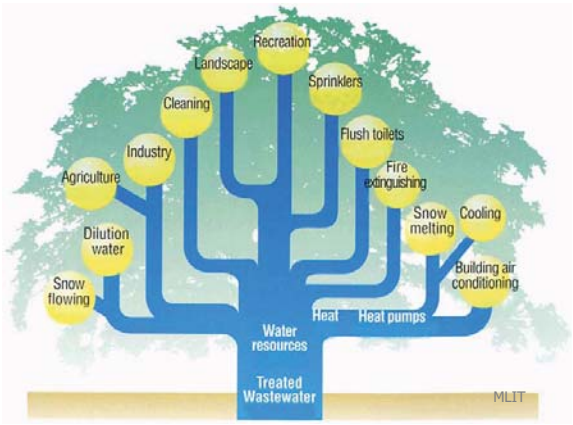
- Untreated wastewater may include waterborne infectious bacteria, protozoa, viruses, helminthes and hazardous chemicals
- Evaluate a trade-off between the benefits and potential health risks of application
- Inappropriate application of reclaimed wastewater may cause contamination of surface, groundwater & soil

Hazard in Reclaimed Wastewater

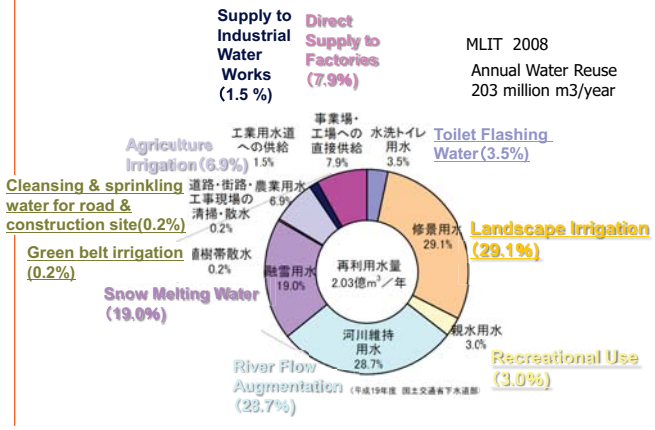
(Tanaka , 2002)

	Urban Application	Agricultural Irrigation	Environmental Application	Potable Reuse
	Toilet flushing, Process water, Urban irrigation	Vegetable eaten in raw, Crop, Flower	Recreational use, River flow augmentation	Indirect, Groundwater recharge
Pathogenic Risk	○	○	○	○
Chemical Risk (human)	?	○	?	○
Chemical Risk (ecosystem/ environment)		△	○	△

Beneficial Use of Reclaimed Wastewater in Japan



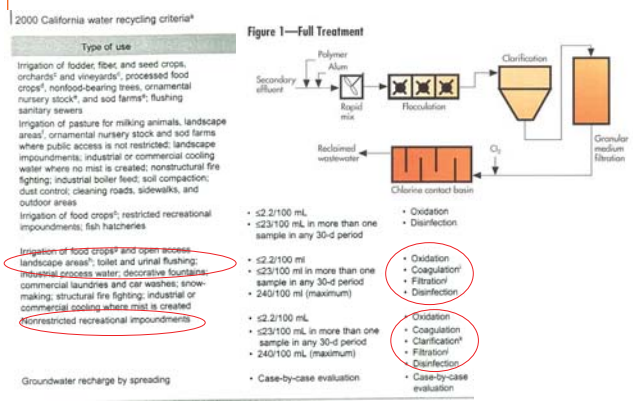
Beneficial Uses of Reclaimed Wastewater in Japan



Reuse Criteria of Urban Use in Japan(MLIT,2005)

		E. coli ND/100ml	E. coli ND/100ml	Total Coliforms 1000/100ml	E. coli ND/100ml
	Standards Applying Location	Flushing Water	Sprinkling Water	Water for Landscape Use	Water for Recreational Use
Escherichia Coli	Exit of treatment facility for reuse	Not detectable [1]	Not detectable [1]	Refer to remarks [1]	Not detectable [1]
Turbidity		(Control target value) 2 degrees or less	(Control target value) 2 degrees or less	(Control target value) 2 degrees or less	2 degrees or less
pH		5.8~8.6	5.8~8.6	5.8~8.6	5.8~8.6
Appearance		Shall not be distasteful	Shall not be distasteful	Shall not be distasteful	Shall not be distasteful
Chromaticity		— [2]	— [2]	40 degrees or less [3]	10 degrees or less [3]
Odor		Shall not be distasteful [3]	Shall not be distasteful [3]	Shall not be distasteful [3]	Shall not be distasteful [3]
Residual Chlorine	Responsibility demarcation point	(Control target value) Free residual chlorine: 0.1mg/L or more; or combined residual chlorine: 0.4mg/L or more [4]	(Control target value) [4] Free residual chlorine: 0.1mg/L or more; or combined residual chlorine: 0.4mg/L or more [4]	Refer to remarks [4]	(Control target value) [4] Free residual chlorine: 0.1mg/L or more; or combined residual chlorine: 0.4mg/L or more [4]
Facility Standards	—	Sand filtration facility or facility with function equivalent to sand filtration or better shall be installed.	Sand filtration facility or facility with function equivalent to sand filtration or better shall be installed.	Sand filtration facility or facility with function equivalent to sand filtration or better shall be installed.	Precipitation + sand filtration facility or facility with function equivalent to precipitation + sand filtration or better shall be installed.

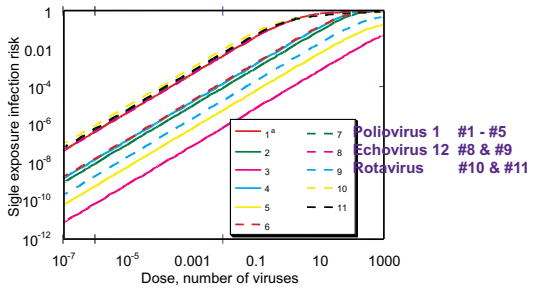
California Wastewater Reclamation and Reuse Criteria



Safety depends upon

- Pathogen type (ability of infection)
- Amounts of Ingested Pathogens
  - Pathogen concentration in reclaimed water
  - Amount of water intake
  - Degradation of pathogens in the environment
- Exposure frequency
- Annual infection (mortality/mobility) risk by some pathogens can be quantitatively estimated depending on reuse scenarios

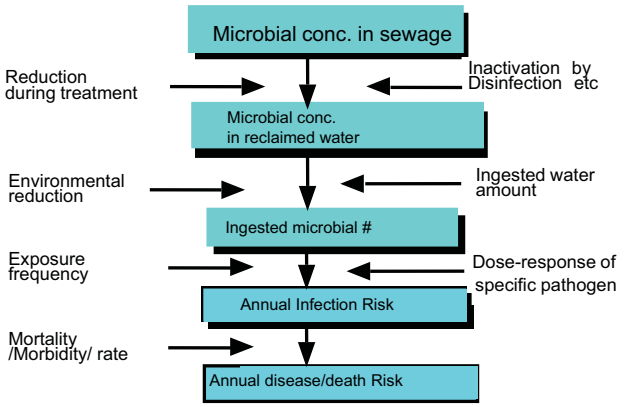
Dose-Response Model for Enteric Viruses



(Tanaka et al., 1995)

Microbial Quantitative Risk Assessment (QMRA)

13



(Tanaka et al., 1995)

Risk Management

14

- **Acceptable/tolerable risk**
  - **USEPA assumes 10^{-4} /year of infection risk acceptable for drinking water(1988)**
  - **WHO & Australian Guideline for Water Reuse assumes 10^{-6} of DALYs acceptable**
    - **DALYs = Disability Adjusted Life Years**
      =YLDs(Years Lived with Disability) + YLLs(Years of life lost)
- **Adequate removal efficiency for specific pathogens can be estimated quantitatively**

To Achieve Goals

15

- **Appropriate wastewater treatment for effective disinfection**
- **Additional treatment if necessary**
- **Alternative is to take longer time before exposure / water storage/ sunlight maturation etc**
- **Consider multiple-barrier concept including application practices besides treatment /irrigation method, harvesting period after irrigation etc**

Reuse Scenario

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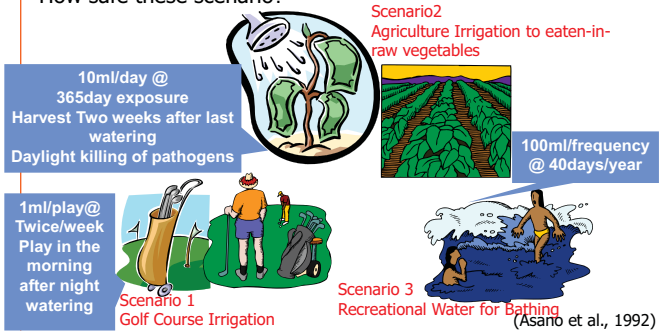
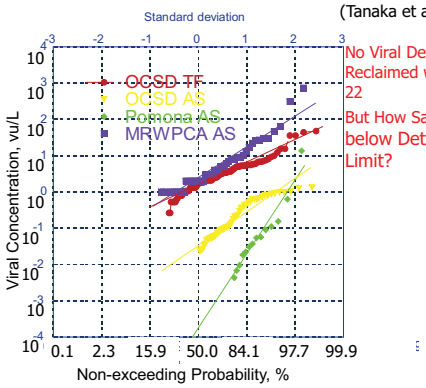
California Title 22 Facilities（Biological treatment followed by coagulation, sedimentation, filtration and chlorination to achieve 5-logs reduction of viruses)
How safe these scenario?



(Asano et al., 1992)

Viral Occurrence in STP Effluent in CA

17



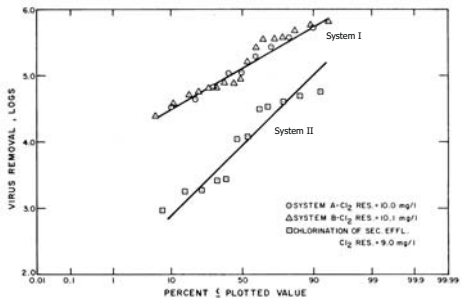
(Tanaka et al., 1998)

No Viral Detection in Reclaimed water by Title 22

But How Safe even below Detection Limit?

Process Reliability of Title 22 Reuse Facility

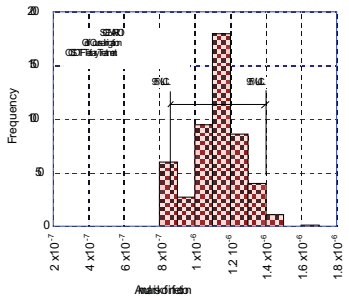
18



Log-Virus Removal Efficiency of Water Reclamation Process complying with Title 2 in Pomona virus study (Parkhurst, 1977)

Example of Monte Carlo Simulation

(Tanaka et al., 1998)



Infection Risk of Golf Player by course irrigation

Annual Infection risk

(Tanaka et al., 1998)

Tertiary treatment		Treatment system: OCSDTF	OCSDAS	PomonaAS	MRWPCAAS	
System I Full Treatment (5.2log removal)	Scenario I	1.4E-06	1.1E-07	5.5E-07	6.0E-06	Golf course Irrigation Agriculture Irrigation Swiming Water
	Scenario II	5.3E-09	3.7E-10	1.5E-09	2.1E-08	
	Scenario III	1.3E-04	1.3E-05	1.0E-04	6.8E-04	
System II Direct Cl2 of secondary effluent (3.9 log removal)	Scenario I	2.8E-05	2.2E-06	1.1E-05	1.2E-04	Golf course Irrigation Agriculture Irrigation Swiming Water
	Scenario II	1.0E-07	7.5E-09	2.9E-08	4.1E-07	
	Scenario III	2.6E-03	2.6E-04	2.1E-03	1.3E-02	
System IV Unchlorinated secondary effluent (0 log removal)	Scenario I	1.9E-01	1.7E-02	7.3E-02	5.3E-01	Golf course Irrigation Agriculture Irrigation Swiming Water
	Scenario II	8.3E-04	5.9E-05	2.3E-04	3.3E-03	
	Scenario III	1.0E+00	6.2E-01	6.7E-01	1.0E+00	

Required Viral Reduction in Reclamation Process to Assure the safety equivalent to 10-4/year

21

(Tanaka et al., 1998)

	A STP	B STP	C STP	D STP
Golf course Irrigation	3.9—Log	2.7 —Log	2.3 —Log	3.9 —Log
Irrigation for raw eaten vegetable	1.5 —Log	0.4 —Log	0.0 —Log	1.5 —Log
Recreation (Bathing)	5.8 —Log	4.6 —Log	4.2 —Log	5.8 —Log

USEPA assumes annual one infection per 10 thousand population is acceptable for drinking water

Basic Research Program by Japan Science and Technology Agency

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Innovative Technology and System for Sustainable Water Reuse

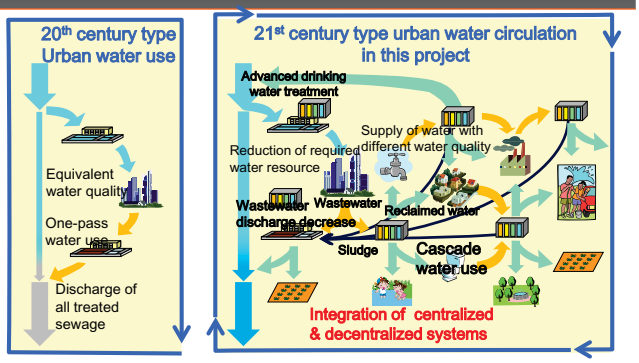
Development and Evaluation of Water Reuse Technologies for the Establishment of 21st century type Water Circulation System

Fiscal Year 2009-2014

Team Leader	Hiroaki TANAKA	Kyoto University
Group Leader	Yoshihisa SHIMIZU	Kyoto University
	Hiroo TAKABATAKE	Toray Industries, Inc.
	Yasuhiro KATO	METAWATER Co., Ltd.
	Masashi OGOSHI	National Institute for Land and Infrastructure Management
	Yutaka SUZUKI	Public Works research Institute
	Tadao MIZUNO	Kyoto university
	Shuhei TANAKA	Kyoto University

Requirements for 21st century type urban water cycle

23



Development of new water treatment system eg Membrane and O_3 process
→ Shift from ONE-PASS to CASCADE WATER USE
⇒ Urban Water Circulation System requiring lower abstraction from natural water resources and emiting less environmental pollutants

Project Research Scheme

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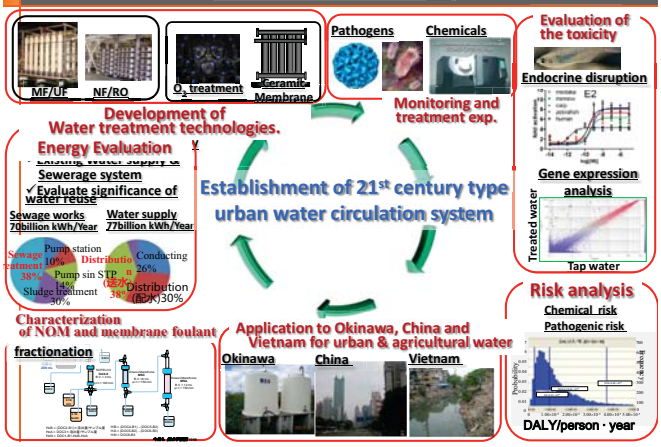
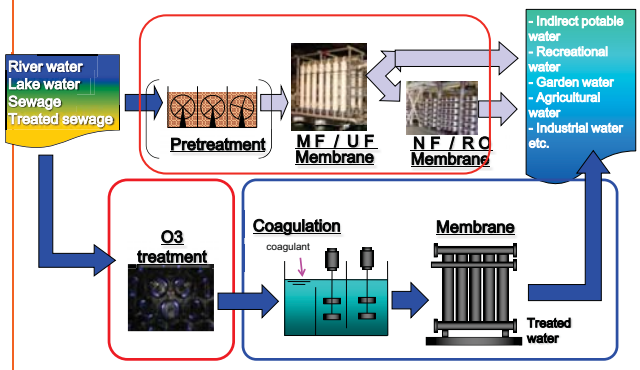
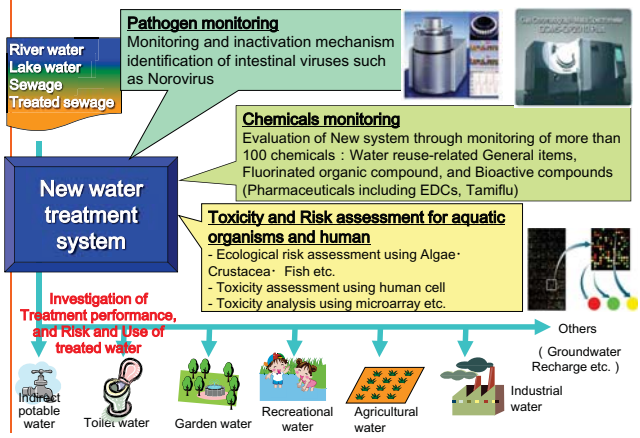


Development of new water treatment system

System combined with Organic Membrane, Inorganic Membrane, O_3 and AOPs



Trace chemicals· Byproducts· Virus· Toxicity monitoring



Risk Management Strategy of Water Reuse

Risk Management by Hazard Assessment for Critical Control Point(HACCP)

Systematic Preventive Methodology for Management of Critical Risk Applications for Risk Management of Food, Drinking Water etc (FAO, WHO)

Initial 5 Step of HACCP 7 Principles of HACCP

- Team Organization
- Product Explanation
- Product Instructions
- Preparing Process Flow Diagram
- Verifying Process Flow Diagram

- Identifying Hazard & Prevention
- Identifying Critical Control Point
- Setting Critical Level(CL)
- Determining Monitoring Methods
- Setting Improvement Action
- Verifying HACCP Plan
- Documentation and Record

Applying and verifying Water Application Scenarios Expanding further development

Identification of Critical Control Points

·Extracting Hazards, considering their frequency and effects,
·Identifying critical control point based on risk level (importance of management)

Where evaluation takes into consideration of results of Quantitative Microbial Risk Assessment(QMRA), DALYs etc in for effects

(Okamoto, 2011)

Risk Evaluation of Water Applications

Human Health Risk Evaluation ～Exposure Scenario～

·Classification of Increasing Future Application (1/2)

Application	Major Usage	Persons exposed to risk	Risk Scenario
Agricultural Water	Rice Leafy vegetable (raw) Leafy vegetable (processing) Root vegetables (radish etc.)	Farmer Consumer Processing worker Neighborhood	Pollution of crops by pathogens (Consumer) Accumulation of pollutants in the crops (Consumer) Indirect ingestion (Farmer or Neighborhood) Risk is different according to kinds of crops
Recreational Water	Bathing	·Workers ·Public(Children)	Unintentional Drink during recreation Intake on hand
Landscape Water	Pond· Impoundment Fountain·Fall	Workers· Visitors Public(Children)	Splash/mist Unintentional Drink by Children
Urban Irrigat	(Lawn Garden) Golf Course· Ball Park, Succor Stadium	Workers· Residents Players Public(depending on irrigation method)	Intake by Sprinkling Water Unintentional Drink by Children In-directive Exposure of Public Access

(Okamoto, 2011)

Risk Evaluation of Water Applications

Human Health Risk Evaluation ～Exposure Scenario～

·Classification of Increasing Future Application (2/2)

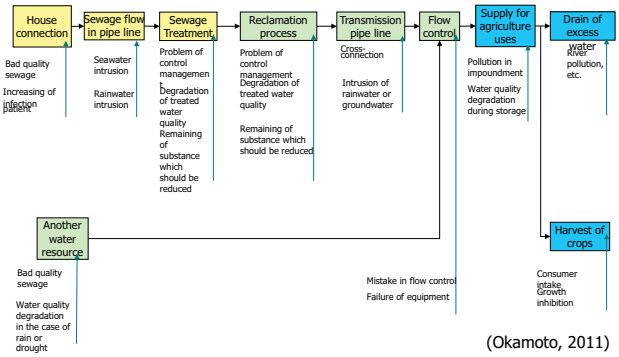
Application	Major Usage	Persons exposed to risk	Risk Scenario
River Flow Augmentation		Residents, Public (Fishing, boat etc)	·Unintentional Drink ·Accidental drink by children
Industrial Water	Cooling tower Commercial water (Cleaning , Car washing)	·Employees ·End-users ·Residents near manufactures	·Dermal intake by aerosols (Emplyees, Residents) ·Dermal exposure by end-users
Flashing Water	Flashing Toilet Water	Users Workers	Indirect intake by aerosols (Users, Workers)
Indirect Potable Use	Groundwater Recharge Reservoirs(Drinking water sources)	Drinking water users	Drinking water
Others	Dust prevention water Use Snow melting water Extinguishing fire water	·Water users ·Workers	Splashing water to workers, other public

(Okamoto, 2011)

Risk Management Method of Reclaimed Water

Investigation of the reclaimed water risk management based on HACCP

- Assumed hazard was investigated in each process of **agricultural uses**



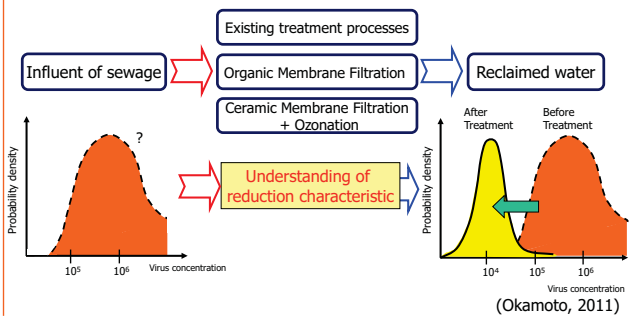
(Okamoto, 2011)

Development of Microbial Risk Assessment Method of Reclaimed Water

31

Monitoring of pathogen concentration
- Clarification of virus concentration in water, and virus reduction of reclamation processes

Evaluating reuse applications of the reclaimed water

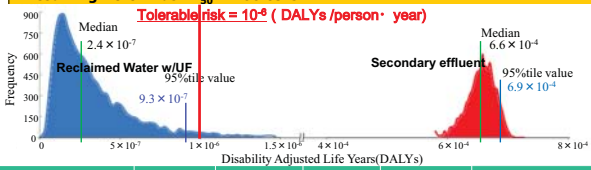


(Okamoto, 2011)

Evaluation of pathogenic &chemical risk of reclaimed water to human

32

- ✓Ex. of Secondary effluent w/ PAC/UF (Assuming 3.86-Logs reduction)
- ✓Application scenario : Farmer infected by Noro virus in agriculture irrigation
- ✓Assuming Noro virus ID_{50} = 100 cells



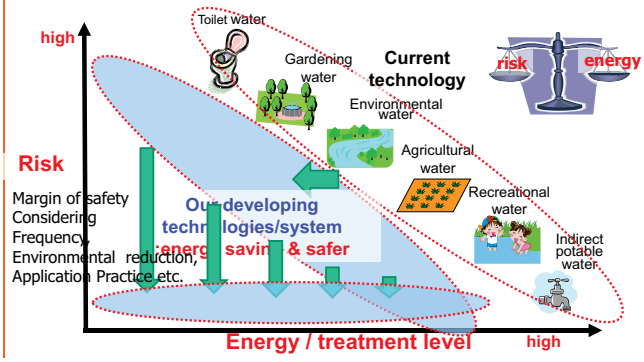
Application	Target	Exposure condition	Intake per one work	Intake frequency (day/year)	95% value of DALY (DALY/person・year)
					ID_{50}=100 for NV
Paddy field	Worker	Indirect ingestion	0.3 mL	27.2	3.8×10^{-6}
Flower planting			0.1 mL	20	9.4×10^{-7}

- ✓Reclaimed water can be used for irrigation to flower planting
- ✓Rice paddy irrigation might require extra reduction

Overcoming Risk & Energy (Cost) Trade-off

33

- ✓Less environmental impact /energy spending urban water system
- ✓Treatability of various risk agents of new treatment technology
- ✓Proposal of Risk-based water usage considering energy–risk trade-off



Thank you for your attention !

Contact : htanaka@biwa.eqc.kyoto-u.ac.jp

Further information of this project will be obtained by
http://www.wcs21st.jp/member/index.html

And Poster Session in this conference hall

International Workshop on Reclaimed Water Use in Urban Area
-From Water Quality to Water Safety Management for Water
(Jan. 10, 2012@Kitakyushu, Japan)

Wastewater Reclamation and Reuse in China
—Regulations and Water Quality Management—

HU Hong-Ying
School of Environment/Graduate School at Shenzhen
Tsinghua University, Beijing/Shenzhen, China
Jan., 10, 2012

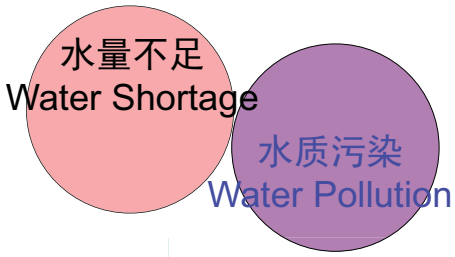
OUTLINE

- Water Environmental Problems in China
- Regulations and Policies for Water Reuse
- National Criteria and Standards of Reclaimed Water
- Reclaimed Water Reuse in Beijing
- Challenges for Risk Management of Reclaimed Water
- Future Works

1.Water Environmental Problems in China

Water Environ. Problems in China

中国面临的主要水环境问题



Water Environ. Problems in China

(1)水资源短缺危机(Water Shortage)

- Water shortage

Per-capital 2,200 m^3/a, i.e., 1/4 of world average
Beijing: only about 300 m^3/a. capital

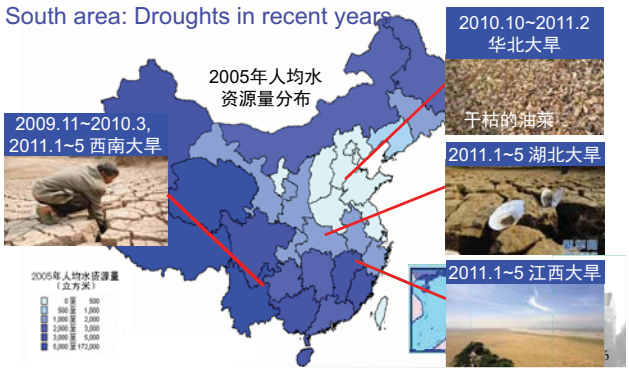
- Unbalanced distribution of water resource

Geographical distribution：More at south, less at north; annual rainfall <400mm/a area: 45%
Seasonal distribution：Rainfall at arid and semi-arid region concentrates on July, August, and September (50% of the total volume)

Water Environ. Problems in China

(1)水资源短缺危机(Water Shortage)

North area: Water resource shortage for a long time
South area: Droughts in recent years



Water Environ. Problems in China

(2)水质污染危机/ Water Pollution

Water quality classes in China

Class I	**Headwaters of a water resource**
Class II	**1st class of drinking water resource**
Class III	**2nd class of drinking water resource**
Class IV	**Water resource for industrial use**
Class V	**Water resource for agriculture use**
Below Class V	**Can not be used for any purpose**

Water Environ. Problems in China

(2)水质污染危机/ Water Pollution

National standards of surface water quality (mg/L)[a]

Class	I	II	III	IV	V
NH_3-N	0.15	0.5	1.0	1.5	2.0
T-P	0.02 (0.01)[b]	0.1 (0.025)[b]	0.2 (0.05)[b]	0.3 (0.1)b	0.4 (0.2)[b]
T-N[b]	0.2	0.5	1.0	1.5	2.0

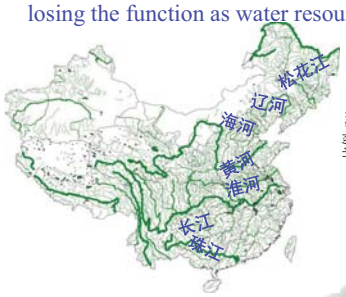
[a] Selected from GB3838－2002
[b] For lake and dam only

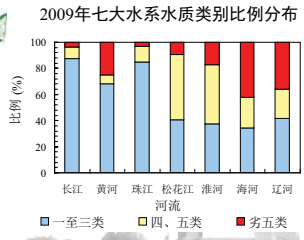
Water Environ. Problems in China

(2)水质污染危机/ Water Pollution

Pollution of the seven water systems is still serious

In the Haihe River, water quality of 42% sections are Class V, losing the function as water resource, landscape and others





Wastewater Reuse in China

Available Water Shortages
One of the limits of economic and development in China

Wastewater Reclamation & Reuse
Essential approach for conserving and extending available water supplies

2.Regulations and Policies for Water Reuse

National Program of Regulations and Policies

National Program
Issues: Water Conservation
Water Reuse

Regulations & Policies
- Programs & plans
- Treatment system & techniques
- Industry standards
- Promotion & Management

Local: Demonstration projects
Drivers: Requirements
Encouragement

Progress of National Regulations and Policies

1996 MOC (建设部)《城市中水设施管理暂行办法》
- Promotion of the use of reclaimed water

2000 The Sate Council (国务院)《关于加强城市供水节水和水污染防治工作的通知》
- Regulations on wastewater treatment utility

2003 MOC (建设部)《关于进一步加强城市节约用水和保证供水安全工作的通知》
- Emphasis of water conservation and water supply security

2004 The Sate Council (国务院)《关于推进水价改革促进节约用水保护水资源的通知》
- Combination of water resource development and water pollution control
- Comprehensive promotion of wastewater reuse

2005 NDRC (发改委)《中国节水技术政策大纲》
- Promotion of municipal wastewater recycle technology
- Optimization of recycle technology and distribution system

2006 MOC (建设部)《城市污水再生利用技术政策》
- Conducts of criteria and standards
- Guidance for development of recycle technology and relevant equipments
- Reference of urban water environment management

Local Regulations and Policies—Beijing

❖ Beijing:

❖ In 1987: Management Regulation of Reclaimed Water Facility in Building of Beijing 《北京市中水设施建设管理试行办法》

The first regulation released in China. Reclaimed water treatment facilities were required in the new construction projects.

- In 2002: Master Plan Outlines of Municipal Wastewater Reclamation in Urban Area of Beijing" 《北京市区城市污水处理厂再生水回用总体规划纲要》

  Reclaimed water capacity must be promoted within the years from 2002 to 2008.
- Beijing 2008 Olympic Games bid report《2008年奥运会申办报告》

  The recycle rate of wastewater was promised to elevated to 50% . the rate reached to 60% in 2007 ahead of schedule.

Local Regulations and Policies—Tianjin

❖ Tianjin:

In 2003, *"Management Regulation of Wastewater and Reclaimed Water in Tianjin"* (《天津市城市排水和再生水利用管理条例》)

- Principles of wastewater and reclaimed water management: Unified planning, systematic construction, integration of construction-maintenance- management
- Treatment principle: Combination of centralized and decentralized Treatment process.
- Industrialization: variety of investment modes were encouraged to promote the industrialization of wastewater treatment and water reclamation.

3. National Criteria and Standards of Reclaimed Water

Technical Policy

❖《National policy for water saving technologies》 (2005)

• Technologies of municipal wastewater reclamation and reuse
- Municipal wastewater reclamation and reuse
- Building reclaimed water
- Subcommunity wastewater treatment and reuse

• Technologies of industrial reuse
- Recirculating water system
- Steam condensate reuse
- Wastewater reuse and "zero discharge"

Technical Policy

❖《Technical policy for municipal wastewater reclamation and reuse》 (2006)

- Guideline for the criteria and standards of municipal wastewater reclamation and reuse
- To lead the development of technologies and devices of wastewater treatment
- Technical basis of urban landscape construction, water environment and wastewater management

Technical Policy

❖《Technical policy for municipal wastewater reclamation and reuse》 (2006)

Goal of Recycling Rate

City of water shortage	Recycling rate(%)	
	2010	2015
Northern areas	10~15	20~25
Southern coastal areas	5~10	10~15


Tianjin Beichen


Tianjin Jizhuangzi

Design Criteria

Municipal Wastewater
- 《Code for design of wastewater reclamation and reuse》
- 《Code of design for building reclaimed water system》

Industrial Wastewater

2003 — 2008 — 2011

- 《Code for design of industrial recirculating cooling water treatment》
- 《Code for design of wastewater treatment and reuse of chemical industry》
- 《Technical specifications for wastewater treatment and reuse of iron and steel industry (draft)》

Water Quality Standards

❖Standards for the reuse of urban recycling water

- 2002: 《Classified standard》 《Water quality standard for urban miscellaneous water consumption》 《Water quality standard for scenic environment use》
- 2005: 《Water quality standard for industrial uses》 《Water quality standard for groundwater recharge》
- 2007: 《 Water quality standard for farmland irrigation water》
- 2010: 《 Water quality standard for green space irrigation》

4. Reclaimed Water Reuse in Beijing

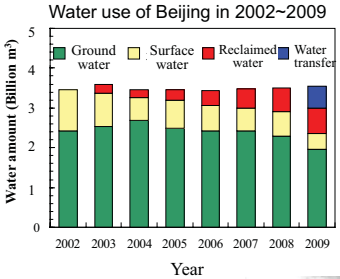
Wastewater reclamation and reuse in Beijing

Purpose of reclaimed water reuse
- Agricultural irrigation
- Industry
  - → Large volume of water
- Water resource replenishment
- Landscape
- Municipal utility
  - → High probability of contaction with people

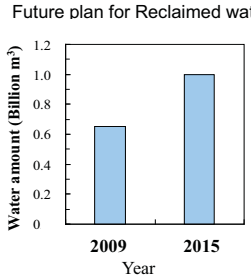
Wastewater reclamation and reuse in Beijing

- In China, reclaimed water is an important water resource in big cities, including Beijing and Tianjin.
- In 2009, Beijing's reclaimed water amount was18% of total water consumption.

Water use of Beijing in 2002~2009

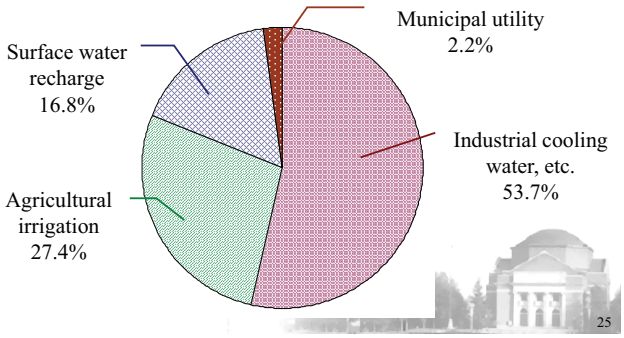


Future plan for Reclaimed water



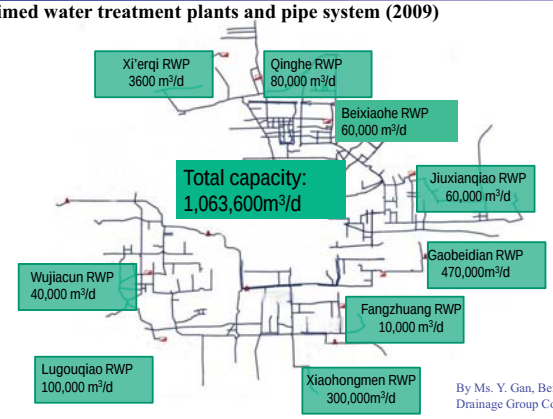
Wastewater reclamation and reuse in Beijing

Reclaimed water supply of Beijing Drainage Group Co. Ltd. in 2009 (18% of total water supply)



Wastewater reclamation and reuse in Beijing

Reclaimed water treatment plants and pipe system (2009)

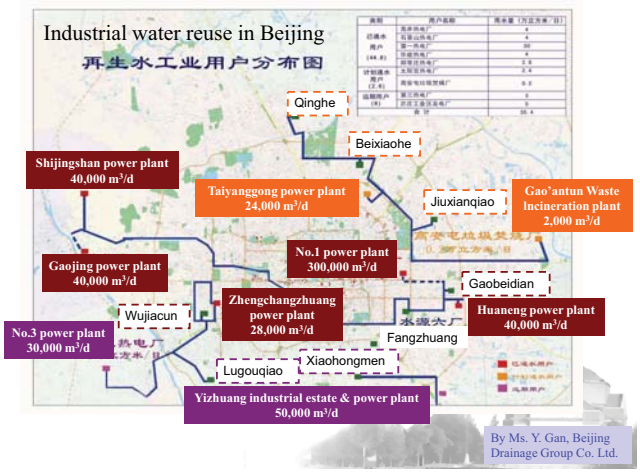


By Ms. Y. Gan, Beijing Drainage Group Co. Ltd.

Usage of reclaimed water in Beijing

By Ms. Y. Gan, Beijing Drainage Group Co. Ltd.

Industrial water reuse in Beijing



By Ms. Y. Gan, Beijing Drainage Group Co. Ltd.

By Ms. Y. Gan, Beijing Drainage Group Co. Ltd.

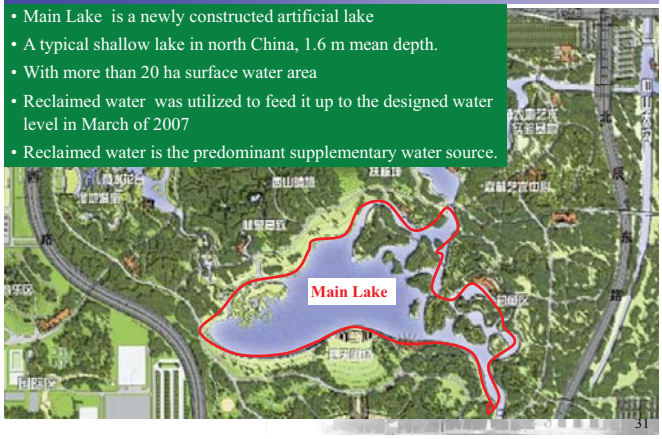
Water environment in Olympic Park

(Olympic Games，Beijing 2008)

- Olympic Park locates at the north end of the axis of Beijing city and was designed as an ecological park with waters and hills.
- The whole water system was designed as Chinese dragon shape.

Main Lake in the Beijing Olympic Forest Park

- Main Lake is a newly constructed artificial lake
- A typical shallow lake in north China, 1.6 m mean depth.
- With more than 20 ha surface water area
- Reclaimed water was utilized to feed it up to the designed water level in March of 2007
- Reclaimed water is the predominant supplementary water source.



Reclaimed water reuse in Olympic Park

Qinghe Reclamation water plant: Total capacity 80,000 m^3/d (60,000 m^3/d supplying in Olympic Park)

Beixiaohe Reclamation water plant: Capacity 60,000 m^3/d (MBR process)

Water quality requirements of water reuse in Beijing

- The requirement for the quantity and quality of the reclaimed water increase continually because of the water shortage.
- So water quality upgrading become an alternative way to develop water resources .
- In 2007, Beijing government proposed to upgrade the water quality of reclaimed water to reach the surface water environmental quality standards in Class Ⅳ, to recover the function of surface water environment.

The water quality requirements of water reuse in Beijing

Comparisons of the different standards

Standards / Water Quality (mg/L)	Wastewater discharge standards		Surface water
	Class B	Class 1A	Class Ⅳ
CODcr	60	50	30
T-N	20	15	1.5(10)
NH_4^+-N	8(15)	5(8)	1.5
T-P	1	0.5	0.3
SS	20	10	

COD, Nitrogen and phosphorus will be more strict of reclamation process.

5. Challenges for Risk Management of Reclaimed Water

Pollutants in wastewater and their risks

- Pathogenic organisms
- Toxic chemicals
  - -Disinfection by-products(DBPs)
  - -Persistent organic pollutants
  - -Endocrine-disruptors (EDCs)
  - -PPCPs
- Nitrogen, phosphorus → Algae bloom → Landscape damage

Healthy risk

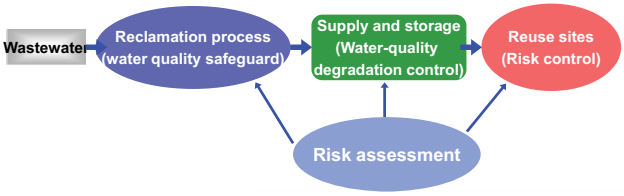
Ecological risk

Emerging pathogens & chemical pollutants !!

Safety evaluation and risk management of reclamation water!

Pollutants in wastewater and their risks

Strategy for Risk Management of Wastewater Reclamation and Reuse



5.1 Pathogens of concern in wastewater

Pathogens in wastewater cause immediate and acute disease.

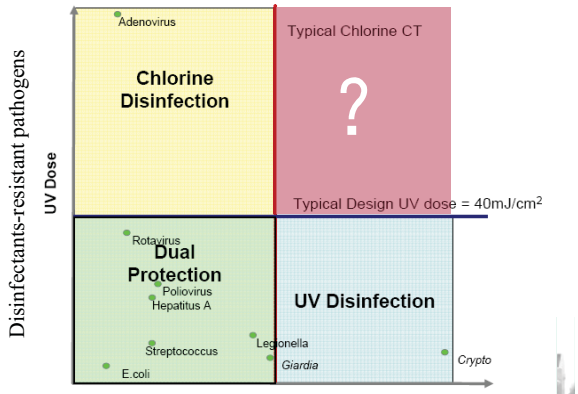
Pathogen	Disease	Conc. (CFU/100 mL)
Fecal coliform	diarrhea	10^4-10^9
Fecal streptococcus		10^4-10^6
Shigella		1-1000
Salmonella		1-1000
Parasite eggs		1-800
Enteric viruses	diarrhea, respiratory and liver damage	100-50000
Giardia lamblia	diarrhea	50-10^4

Disinfection is the necessary process for water reuse

5.1 Pathogens of concern in wastewater

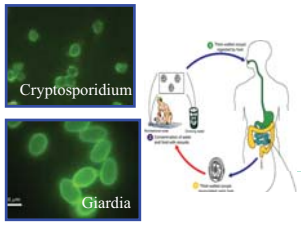
- Evaluation index of reclaimed water disinfection
  - Agar-plate cultivation (colonies) is used to determine the existence of pathogens in reclaimed water
  - 80% of microorganisms are viable but non-culturable (VBNC)
  - Novel pathogens of concern, such as norovirus, *Cryptosporidium* and *Giardia*, etc.
  - Harmful genes are emerging as new contaminants of pathogens

5.1 Pathogens of concern in wastewater

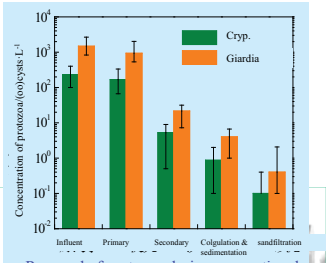


Disinfectants-resistant pathogens

- *Cryptosporidium & Giardia*
  - Two novel protozoa with high pathogenicity and chlorine resistance as contaminants in water and wastewater
  - Difficult to detect because of low recovery rate and high cost



Protozoa and their infection route



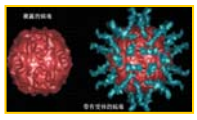
Removal of protozoa during conventional wastewater treatment process

Disinfectants-resistant pathogens

- Viruses
  - Hepatitis viruses
  - Norovirus
  - Rotavirus
  - Poliovirus
  - Coxsakie virus
  - Echovirus

Long survival in water

Low dosage to infection



Difficult to be inactivated by conventional disinfectants

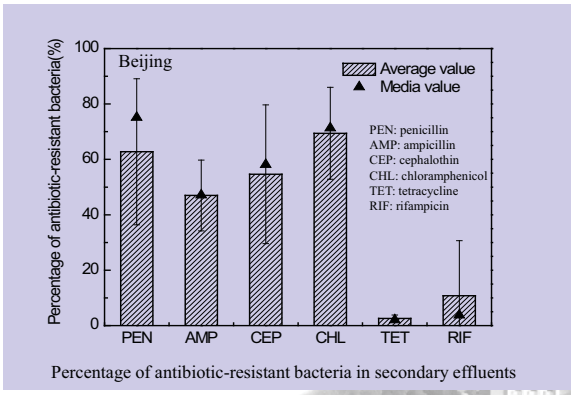
- Harmful genes
  - Virulence genes
  - Antibiotic resistance genes

"Super bacteria" in wastewater

Harmful genes in reclaimed water

- Plasmids with multiple resistance genes and virulence factors release from bacteria after inactivaiton
  - Broad spectrum β-lactamase genes
  - Virulence island in *E. coli* O157:H7(including *eae* in LEE island, *vt* genes in prephophage, *hly*, *katP*, *espP*, *toxB* and *stcE* genes in pO157 etc.
- Phage with Shiga-toxic genes in wastewater

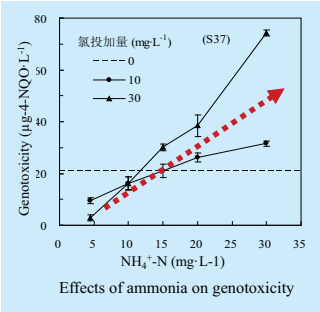
"Super bacteria" in wastewater



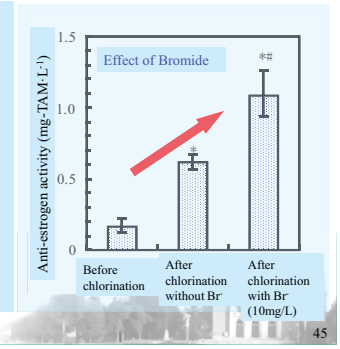
Percentage of antibiotic-resistant bacteria in secondary effluents

Disinfection by-products

- Increase of genotoxicity and anti-estrogen activity after chlorination.

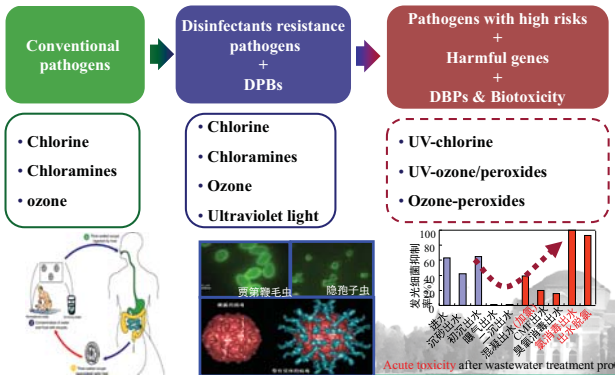


Effects of ammonia on genotoxicity



Development of advanced disinfection technology

N: Control of pathogens with high risks and disinfectants by-products (DBPs)



Acute toxicity after wastewater treatment process

5.2 Toxic pollutants and their risks

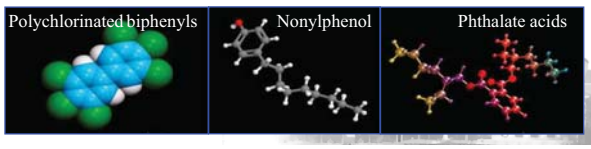
有毒有害污染物 Toxins

- Persistent organic pollutants (POPs) 持久性有机污染物
- Pharmaceuticals & personal care products (PPCPs)药品与个人护理品
- Endocrine disruptors (EDCs) 内分泌干扰物
- Nanoparticles 纳米颗粒物
- Emerging disinfection by-products 新兴消毒副产物

Risks

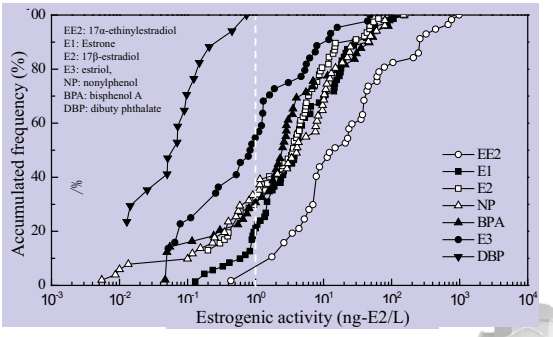
- Toxicity
- Accumulation
- (apparent) persistence

Emerging toxins are detected in wastewater



Toxic pollutants and their risks

Endocrine disruptors Chemicals (EDCs)



Estrogenic activity of typical endocrine disruptor in the effluent of wastewater treatment plants

5.3 Challenges of toxic chemical evaluation

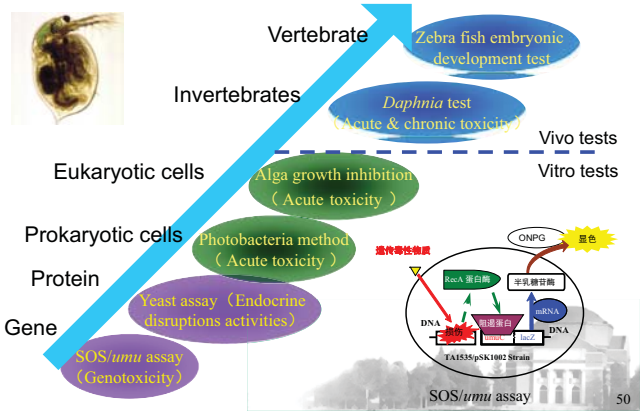
Importance of bio-toxicity tests (bioassay)

- Many pollutants/DBPs are unidentified or uncharacterized by existing analysis methods.
- Toxicities of many pollutants/DBPs remain unknown.
- Mixture effects of pollutants/DBPs toxicity are complex.

Bio-toxicity tests are more comprehensive and intuitionistic for evaluating risks induced by chemical pollutants/DBPs.

Measuring toxicity changes during chlorine disinfection is important for evaluating and guaranteeing the safety of reclaimed water.

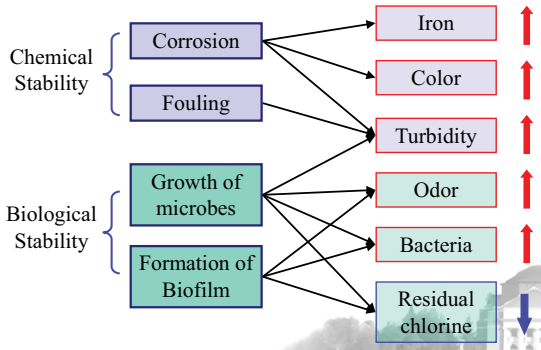
Biotoxicity tests



SOS/*umu* assay

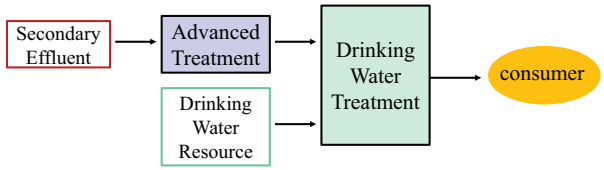
5.4 Reclaimed Water Distribution System

❖ Control of water quality deterioration

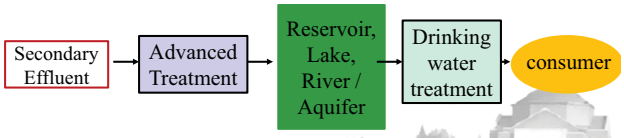


5.5 Water resource replenishment-health risk

• Direct Supplement



• Indirect Supplement（planned）



• Indirect Supplement（Unplanned, eg river basin）

6. Future Works

污水再生利用课题
Issues on Wastewater Reclamation and Reuse

❖ 再生水水质安全问题 Reclaimed water quality

- ✓ 病原微生物去除 Effective and safety disinfection
- ✓ 微量污染物去除 Micro-pollutants removal
- ✓ 氮磷高标准去除 Advanced nutrient removal
- ✓ 脱盐/浓缩液处理 Desalination/brine treatment
- ✓ 用户特定要求 User's special requirements

污水再生处理工艺 Advanced wastewater reclamation process

水质和运行监管体系
Water quality and operation monitoring system

污水再生利用课题
Issues on Wastewater Reclamation and Reuse

- 再生水长期利用风险/累积风险 Long term/ accumulative risks
  - ✓灌溉利用：污染物的积累（土壤和地下水污染）
    Agricultural and green irrigation (soil and groundwater pollution)
  - ✓景观/环境利用：有毒有害污染物积累
    Accumulation of POPs, metals and harmful genes
- 工业废水和生活污水混合处理系统的水质安全保障
  Reclaimed water safety management for the combined treatment process of industrial and municipal wastewaters
- 再生水储存Storage of reclaimed water

污水再生利用课题
Issues on Wastewater Reclamation and Reuse

- 污水再生利用系统：集中型还是就地就近型？
  Centralized system or onsite/point-of-sale system ？
  - ✓ 集中型 Constraints of Centralized system
    - －管网投资高 High pipeline costs
    - －难以同时满足不同用户的水质和水量需求
      Difficult to simultaneously meet the various user's requirements in quality and flow-rate
    - －适合污水厂周围及水质要求相同的用户或大水量用户
      Better for the users near a WWTP or have similar quality requirement &larger demand
  - ✓ 就地就近型 Onsite/point-of-sale system
  - ✓ 集中与就地就近相结合 Combination of both systems

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